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54 Device for the measuring of a current flowing in a conductor, in particular in a microstrip, as well as a microstrip for this

Description

Device for the measuring of a current flowing in a conductor, in particular in a microstrip, as well as a microstrip for this.

The invention concerns a device for the measuring of a current flowing in a conductor, in particular in a microstrip, comprising a sensor unit assigned to the conductor, which measures the magnetic field created dependent on the current conduction in the ambience of the conductor.

It is well known that such devices are used in electronic components, for example in relays, and that they there serve the purpose of the measuring of the flowing current. Mostly used, in particular with relays, are strip-shaped conductors. The measuring takes place in such a manner that the sensor unit is arranged close to the surface of the microstrip. If current flows, the microstrip creates a magnetic field, which can be measured by the sensor unit. By approximation the magnetic field strength H of a flat microstrip close to its top results as follows:

$H \approx I/(2B) = \sigma/2$ [A/m] with

H = magnetic field strength
I = current
B = width of the microstrip
σ = surface current density

With limited conductor strength the surface current density is limited by the resistor-conditioned temperature rise and the reduced heat conveyance. Therefore also the attainable magnet field strength is limited. This is particularly relevant for small current values to be measured, since then usually the conductor strengths are very small, and therefore also the surface current density is small. Consequently it is necessary in many cases to take action in order to increase the field strength with a given current. For this purpose a conduction guide is often used. For the

purpose of the strengthening of the field, the conductor is surrounded by a conduction guide device, which exhibits an air gap. The sensor measures the field given in the air gap, which is amplified due to the conduction guide. However, also here certain limitations exist. Assuming a relatively long conduction circuit and a large magnetic susceptibility (> 1000) of the conduction guide device, the magnetic field strength in the air gap results by approximation to:

$H \approx I/L_1$ [A/m], with

H_1 = magnetic field strength in the air gap
I = current
L_1 = length of the air gap

A comparison of the above approximation formulas shows that a strengthening of the field with the conduction circuit is only then favorably implementable, if the width B of the microstrip is clearly smaller than the gap width L_1. The smallest possible gap width is however determined by the sensor dimensions. For sensor units totally enclosed in a housing it is typically approx. 3 mm. Besides these limitations, the conduction guide is expensive due to its complexity, which affects in the long run disadvantageously the costs of the respective component.

The invention faces the problem to indicate a simple device, with which it is also possible to measure very small currents and thus very small magnetic field strengths at conductors, in particular at microstrips.

For the solution of this problem it is intended according to the invention for a device of the type initially mentioned, that the conductor is designed in the shape of a coil exhibiting at least one turn, in whose inside the sensor device is arranged.

The device according to the invention takes favorably advantage of the characteristics of a coil regarding the formation of its magnetic field. The conductor exhibits the shape of a coil, thus possesses at least one turn, whereby the sensor is arranged on the inside, thus in the coil center, and measures the magnetic field created there. Said magnetic field is the larger, the more turns are intended. However,

already in the case of formation of only one turn a considerable strengthening of the field results. The magnetic field strength can here be indicated in approximation:

$H_S \approx (n \bullet 2 \bullet \sigma)/2$ [A/m] with

H_S = magnetic field strength inside the coil,
n = number of turns
σ = surface current density.

The field thus increases with an increasing number of turns, so that it is a particular advantage, that an adaptation to actually given conditions is in such a manner possible, that with extremely low currents a device with several turns is used, whereas with somewhat larger currents to be measured accordingly a lower number of turns is sufficient. A further considerable benefit of the device according to the invention is the fact that relatively badly conducting conductors, in particular microstrips as for example Fe-sheet metals or Si-Fe-sheet metals can be used easily. The problem with these conductors is the fact that for the strengthening of the field the current cannot be increased at will, since otherwise disadvantages resulting from the temperature rise occur and the measurable magnetic field strength is very small. The formation of the conductor according to the invention in form of a coil enables however a sufficient strengthening of the field, which is the reason why such conductor types can also be used.

It has been proven to be particularly suitable, if one or more turns run essentially in one plane perpendicular to the coil axis, since the field generation can be even further improved with such a turn arrangement. The turns itself should exhibit according to the invention a distance to each other that is as small as possible and essentially constant. The turns can be arranged in such a manner that the coil - seen in direction to the coil axis - exhibits a cross section that is essentially polygonal, in particular square, or round, whereby the sensor unit is intended in each case in the inside of the coil.

In order to prevent the effect of any possible external residual fields, as they can be created e.g. by the switching coil of a relay, which can affect the measuring disadvantageously, a particularly suitable further improvement of the invention intends that the conductor is guided in order to create a gradiometer in such a manner, that at least two coils connected which each other are formed, in whose inside in each case a sensor unit is arranged. For this formation according to the invention two parallel coils are intended, which are connected with each other and create in each case fields pointing into varying directions. With this embodiment, any residual fields, as far as they are homogeneous, do not have considerable effect on the measuring. According to the invention the coils can be arranged next to each other or one above the other. Sensor units can be intended in at least two coils, which supply signals or signal contributions that vary in their polarity sign if the measuring field is homogeneous.

It has been proven to be particularly favorable from a manufacturing and production view, if according to the invention the conductor is guided in such a manner that a current supply line is designed at least at one end of the coil or the several interconnected coils, which leads away from said coil or coils, whereby the one or both current supply lines are angled, in particular perpendicular to the plane of the coil. Because it is particularly favorable with microstrips, which due to their shape cannot be easily guided out of the coil plane for the purpose of contact, if directly a suitable current supply line section is intended, which in any case should be arranged at the internal section of the coil. It is however most suitable, if corresponding sections are intended at both ends. According to the invention the conductor itself can be a conductor preferably made in one piece, whereby the device can of course also be made of regular wire conductors, since the strengthening of the field can also be achieved with these.

If the device according to the invention is not designed in form of a gradiometer, a screening device for the sensor unit(s) can be intended in order to prevent any residual field effects. This screening device should surround the coil(s) at least within the area of the sensor

units. The fact that the sensor unit is arranged inside the coil of the device according to the invention permits this simple screening possibility. The coil can be arranged in such a way that it becomes possible, to surround the coil, including the sensor units, to a large extent with one single screen, which is attached subsequently. The screening device according to the invention can be a receiver, which is preferably open only at one side and which is made from a soft-magnetic material, for example a Ni-Fe-alloy, Perminvar or a μ-metal. The receiver can thereby very easily be slid over the coil including the sensor, which simplifies the entire assembly considerably. Furthermore the design as receiver open only at one side has the advantage that a more efficient screening can be achieved than with a structure open at multiple sides. For a particularly effective screening it proved to be suitable, if the coil(s) are designed and if necessary arranged in relation to each other in such a manner and that the current supply lines are arranged and guided in such a manner that the coil(s) is (are) held so deeply in the screening device that the distance of the sensor units held inside the screening device to the opening of the screening device is larger than the distance of the current supply lines in the opening of the screening device.

The inventions concerns besides the device itself furthermore a microstrip for a device according to the invention described above. As already described, this microstrip should exhibit at least a current supply line section. It is to make certain that the microstrip can be made extremely simple and efficiently in high quantities and under optimal utilization of the size of the sheet metal, out of which the microstrip is to be punched appropriately, without too much waste. As solution is thereby intended with a microstrip that it exhibits an oblong, straight-lined coil section for the formation of a coil, at whose one end a section made in one piece and in an angle to the longitudinal axis of the coil section is intended for the formation of a current supply conductor. The microstrip of this embodiment thus essentially exhibits an L-shape. The one current supply conductor is created by means of the angled arranged coil section; the other current supply conductor represents the other end of the straight-lined coil section during this simplest arrangement.

It is however possible to intend also at this end a further section made in one piece and in an angle for the formation of a second current supply conductor. The microstrip of these embodiments evidently exhibits a shape, which makes it possible to arrange the microstrips to be punched out of a sheet metal extremely close besides one other, and therefore to use the sheet metal dimensions to an optimum.

As an alternative to this, a microstrip suitable for the formation of a gradiometers is characterized according to the invention by the fact that it exhibits a first and a second coil section for the formation of two coils which are next to one another, whereby both coil sections run essentially parallel to each other and are connected in one piece by means of a connection section at one of their ends. This microstrip exhibits in its simplest design an essentially U-shaped shape, which permits the formation of a gradiometer. Although the current supply lines are here formed by the ends of the coil sections themselves, a section made in one piece and in an angle to the longitudinal axis of the first and/or the second coil sections can be intended for the formation of a current supply conductor at the free end of the first and/or the second coil section.

Further benefits, features, and details of the invention result from the embodiment described in the following, as well as from the drawings. Showing is:

Fig. 1 a perspective schematic diagram of a device according to the invention with a coil,

Fig. 2 a representation of the principle of the coil arrangement,

Fig. 3 a top view on an uncoiled microstrip of a first embodiment,

Fig. 4 a top view on an uncoiled microstrip of a second embodiment,

Fig. 5 a device according to the invention in form of a gradiometer arrangement,

Fig. 6 a representation of the principle of the coil arrangement with a gradiometer,

Fig. 7 a representation of an uncoiled microstrip of a third embodiment,

Fig. 8 a representation of an uncoiled microstrip of a fourth embodiment,

Fig. 9 a device according to the invention in form of a gradiometer according to a second embodiment,

Fig. 10 a representation of the uncoiled microstrip of the device according to Fig. 9 and

Fig. 11 a schematic diagram of a device according to the invention with a coil with an assigned screening device.

Fig. 1 shows a device 1 according to the invention, consisting of a microstrip 2 and a sensor unit 3. The microstrip 2 is folded multiple times, forming several turns 4, for the formation of a coil, which is essentially rectangular in its cross section in the embodiment shown. The sensor unit 3 is arranged inside the coil. This serves the purpose of measuring the magnetic field strength inside the coil for current conduction through the microstrip 2. Due to the formation of the microstrip 2 in form of the coil the magnetic field in the coil inside can be clearly increased compared to the magnetic field, which is created by a non-folded microstrip. As Fig. 1 and in particular Fig. 2, in which the principle of the coil arrangement is represented, show, all turns 4 in the coil area are situated approximately perpendicular to the coil plane 5. This arranged design is of benefit for the field creation during current conduction (see the conduction arrows drawn in Fig. 2).

As Fig. 1 shows furthermore, two current supply lines 6 are intended at the microstrip 2. The current supply line 6 originating from the internal end of the coil runs thereby essentially toward the coil axis A and is formed by a corresponding section of the microstrip 2 made in one piece. The free end of the strip section forming the coil forms the current supply conductor at the external end of the coil; a section originating accordingly angled is not intended in this embodiment.

Fig. 3 shows a top view on an uncoiled microstrip 2, as it is suitable for the formation of the device 1. Said microstrip consists of an oblong, straight-line coil section 7 and a section 8, which is protruding right-angled from said section 7 in the shown example, which forms the current supply conductor 6. Evidently it is possible due to the essentially L-shaped arrangement of the microstrip 2 to arrange the individual conductors extremely closely next to each other during the production from a sheet metal and therefore to be able to use the size of the sheet metal optimally.

Fig. 4 shows a further embodiment of a microstrip, by means of which a device according to the invention can be produced. This corresponds essentially to the microstrip known from Fig. 3, however the microstrip 9 according to Fig. 4 exhibits at both ends of the coil section 10 two further sections 11 for the formation of suitable current supply lines. This embodiment makes it possible to arrange also at the external end of the coil a current supply conductor, which is protruding angled from the coil. This can be of advantage for the bonding process. As also Fig. 4 shows, the microstrips of this embodiment can be arranged very closely to each other on the sheet metal during production.

Fig. 5 shows an embodiment of the device according to the invention in form of a gradiometer. The shown device 12 according to the invention consists here of two coils 13, which are connected which each other by means of a connector 14. Inside each coil a sensor unit 15 is arranged in each case, whereby Fig. 5 shows only one sensor unit, the arrangement however results from Fig. 6. Fig. 6 shows on the one hand clearly the current conduction through the two coils, as well as the arrangement of the individual turns 16 of the two coils in a position

running essentially perpendicular to the coil axis A. As a result from the direction of the current conduction through the two coils according to Fig. 6 magnetic fields are created which are inversed to each other. This gradiometer arrangement is thereby relatively unsusceptible against external residual fields, as they can be created e.g. by the switching coil of a relay or similar. The two signals of the sensor units are suitably superimposed in such a manner that they cancel each other out for homogeneous external fields.

Finally Fig. 7 shows a first embodiment of a further microstrip 17, which can be used for the formation of the device 12 shown in Fig. 5. This microstrip 17 exhibits two-coil sections 18, which run parallel to each other. At one end both coil sections 18 are joined by means of the connection section 14. Also this design of the microstrip permits a high device complexity in the production sheet metal.

Fig. 8 shows a further embodiment of a usable microstrip. The microstrip 19 shown there consists likewise of two coil sections 20, which are joined together by means of a connection section 21. At the free ends of the coil sections 19 however two further sections 22 are intended, which are protruding essentially right-angled, which are used for the formation of suitable current supply lines, which protrude in a right-angled arrangement towards the coil axis of the respective coils.

Fig. 9 and 10 show a device 23 with two coils 24 located above each other, and a microstrip 25 for the formation of this device 23. The basic design of the device 23 corresponds to that of the device 12 according to Fig. 5, only here the coils 24 are arranged on top of each other. The microstrip 25 consists of two coil sections 26, which are connected by means of the connection section 14. The coil sections here run parallel, however off center to each other. Angled protruding current supply lines can be attached at the ends, which is not shown.

Fig. 11 finally shows the arrangement of a screening device 27 around a measuring device according to the invention exhibiting only one coil. External residual fields can be sufficiently guarded by means of

this screening device 27. The screening device 27 is designed in form of a receiver, which is open only at one side and which is made from a soft-magnetic material, for example a Ni-Fe-alloy, Perminvar or a μ-metal.

The receiver 28 can be slid in a simple way with the open end 29 over the coil arrangement of the device according to the invention. The coil arrangement itself is here designed somewhat oblong, whereby the sensor device 30 is arranged in such a manner inside the coil that it is completely surrounded by the receiver 28.

Patent claims

1. Device for the measuring of a current flowing in a conductor, in particular in a microstrip, comprising a sensor unit assigned to the conductor, which measures the magnetic field created dependent on the current conduction in the ambience of the conductor, characterized by the fact that the conductor (2) is designed in the shape of a coil exhibiting at least one turn (4), in whose inside the sensor device (3) is arranged.

2. Device according to claim 1, characterized by the fact that the one or several turns (4) run essentially in a plane perpendicular to the coil axis (A).

3. Device according to claim 1 or 2, characterized by the fact that the turns (4) exhibit an essentially constant distance to each other.

4. Device according to one of the preceding claims, characterized by the fact that the coil - seen in direction to the coil axis - exhibits a cross section that is essentially polygonal, in particular square, or round.

5. Device according to one of the preceding claims, characterized by the fact that the conductor is guided in order to create a gradiometer in such a manner, that at least two coils (13, 24) connected which each other are formed, in whose inside in each case a sensor unit (15) is arranged.

6. Device according to claim 5, characterized by the fact that the coils are arranged next to each other or one above the other.

7. Device according to claim 5 or 6, characterized by the fact that sensor units (15) are intended in at

least two coils, which supply signals or signal contributions that vary in their polarity sign.

8. Device according to one of the preceding claims, c h a r a c t e r i z e d b y t h e f a c t that the conductor is guided in such a manner that a current supply line (6) is designed at least at one end of the coil or the several interconnected coils, which leads away from said coil or coils.

9. Device according to claim 8, c h a r a c t e r i z e d b y t h e f a c t that the one or both current supply lines are angled, in particular perpendicular to the plane of the coil.

10. Device according to one of the preceding claims, c h a r a c t e r i z e d b y t h e f a c t that the conductor is a microstrip (2, 7, 9, 17, 19, 25).

11. Device according to claim 10, c h a r a c t e r i z e d b y t h e f a c t that the microstrip (2, 7, 9, 17, 19, 25) is made in one piece.

12. Device according to one of the preceding claims, c h a r a c t e r i z e d b y t h e f a c t that a screening device (23) is intended for the sensor unit(s) (26).

13. Device according to claim 12, c h a r a c t e r i z e d b y t h e f a c t that the screening device (23) surrounds the coil(s) at least within the area of the sensor unit(s) (26)

14. Device according to claim 12, c h a r a c t e r i z e d b y t h e f a c t that the screening device (23) is a receiver (24), which is preferably open only at one side and which is made from a soft-magnetic material.

15. Device according to claim 14, c h a r a c t e r i z e d b y t h e f a c t that the coil(s) are designed and if necessary arranged in relation to each other in such a manner and/or that the current supply lines are arranged and guided in such a

manner that the coil(s) is (are) held so deeply in the screening device that the distance of the sensor unit(s) held inside the screening device to the opening of the screening device is larger than the distance of the current supply lines in the opening of the screening device.

16. Microstrip for a device according to one of the claims 1 to 15, characterized by the fact that it exhibits an oblong, essentially straight-lined coil section (7, 10) for the formation of a coil, at whose one end a section (8, 11) made in one piece and in an angle to the longitudinal axis of the coil section is intended for the formation of a current supply conductor.

17. Microstrip according to claim 16, characterized by the fact that at the other end of the coil section (10) a further section (11) made in one piece and in an angle to its longitudinal axis is intended for the formation of a second current supply conductor.

18. Microstrip for a device according to one of the claims 1 to 15, characterized by at least two oblong and essentially straight-line coil sections (18) for the formation of at least two coils which are next to one another or above one another, whereby the coil sections (18, 26) run essentially parallel to each other and are connected in one piece by means of a connection section (14) which connects two coil sections at one of their ends.

19. Microstrip according to claim 16, characterized by the fact, that at the end of at least one coil section (18) a section (22) made in one piece and in an angle to the longitudinal axis of the coil sections (18) is intended for the formation of a current supply conductor.

20. Microstrip according to one of the claims 16 to 19, characterized by the fact that it is produced by using a punching process.